OCCURRENCE OF ANISAKID LARVAE (NEMATODA: ASCARIDIDA) IN FISHES FROM ALASKA AND IDAHO

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ABSTRACT.— All 25 sablefish (*Anoplopoma fimbria*) examined from two bays near Sitka, Alaska, were infected with anisakid larvae. There were 1 to 11 larvae per infected fish, with worms encysted in the musculature of the body wall of 5 fish and in the liver of 4 fish. For the other hosts the viscera was the site of infection. Chinook salmon (*Onchorhynchus tshawytscha*) from Barrow, Alaska, and Obsidian, Idaho, were also infected with anisakid larvae. These data extend the known northern distribution of the anisakids along the Pacific Coast for sablefish and chinook salmon. The pathogenesis of the migratory pathway of anisakid larvae is described, and comments on human health implications are presented.

Anisakine nematodes have been a major problem in the fishing industry for years because their presence reduces the commercial value of fish (Meyers 1979, Wootten and Waddell 1977, Wootten 1978). During the past 10 years it has been observed that two genera, *Anisakis* sp. and *Phocanema* sp., are dangerous to humans in South America and North America who consume raw or poorly cooked infected fish (Jackson 1975, Meyers 1975, Cattan 1976, Kates 1973, Morbidity and Mortality Weekly Report 1975). The primary species observed for this study was *Anisakis simplex*. The disease, anisakiasis, has been recognized in Europe and the Far East for several decades (Oshima 1972, Shiraki 1974, Smith and Wootten 1978). The survival of anisakid larvae in various fish-processing methods has been demonstrated by Hauch (1977). Precautions are necessary in preparing fish for human consumption.

During the last two decades there has been renewed interest in the importance of the anisakine nematodes (Myers 1979, Hadidjaja et al. 1978). Surveys have been conducted throughout the world to determine the occurrence and distribution of the anisakids in fish, especially those hosts of commercial value. The larval worms have recently been reported in a bowhead whale (*Balaena mysticetus*) harvested at Barrow, Alaska, (Migaki et al. 1982) and in fish from Chile (Carvafal 1981, Torres et al. 1983). It appears that these larvae have a worldwide distribution in fish. One study of fish hosts demonstrated the presence of anisakid larvae in 138 species in marine fish and one species of squid (Ono 1975).

One objective of this study was to extend the northern geographical distribution of anisakias and to determine pathogenesis for host tissue. Because of the availability of the main host species, sablefish (*Anoplopoma fimbria*) were studied in Sitka, Alaska, to determine the geographical range of anisakine larvae. A limited number of chinook salmon were obtained from two other sites for study.

The proposed life cycle of *Anisakis* begins with the release of eggs from the adult worm that usually is found in the large intestine of marine mammals (cetaceans and pinnipeds: Myers 1970, Vik 1964, Smith and Wootten 1978). The eggs develop into stage I and II larvae, which are preyed upon by krill and other crustaceans such as *Thysanoessa* sp. (Smith 1971). The larvae penetrate the intestinal tract and develop into stage III larvae in the crustacean host. Fish prey upon the infected crustaceans and become paratenic hosts for marine mammals that are the definitive hosts. In marine mammals the anisakids develop into adult worms and release eggs (Smith and Wootten 1978).

Anisakid larvae found in fish are usually tightly coiled on the mesenteries, liver, and gonads and in the musculature of the body wall. Prusevich (1964) demonstrated that the capsule surrounding the larvae is of host origin and that the inflammatory reaction to the presence of the parasite in the liver of the shorthorn sculpin began during the first few

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Fig. 1. Anisakid larva (AL) encapsulated (EC) in host muscle (HM). (400×)

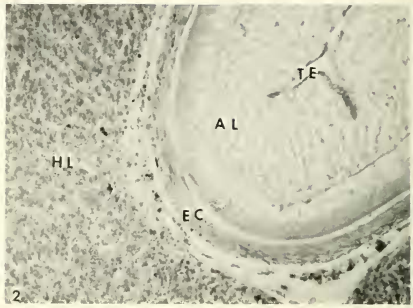

Fig. 2. Anisakid larva (AL) found encapsulated (EC) in host liver (HL). Note the characteristic tripartite esophagus (TE) of the worm. (400×)

hours of the invasion. The musculature of herring was a common sight of infection for the host taken from British marine waters (Davey 1972). The infection in herring was independent of host age or length.

Freshwater fish such as *Hemibarbus barbus* (Ono 1975) and trout (Wootten and Smith 1975) have also been reported as hosts for anisakid larvae.

Materials and Methods

During the summer months of 1978, 25 sablefish (*Anoplopoma fimbria*) were taken by line from Starrigavan Bay and Thompson Harbor, Sitka, Alaska. Sixteen fish were harvested from Starrigavan Bay and nine from Thompson Harbor. Each fish was examined immediately upon death or 24 hours later. The later fish were stored under refrigeration until examined. Infected muscle and liver tissue were fixed in 10% buffered formalin followed by histological preparation by standard methods (Humason 1972). The tissue sections were stained with haemotoxylin and eosin (H + E) and Mallory's Triple, a trichrome stain. During 1982 and 1983 a total of 10 chinook salmon, from the spawning traps near Obsidian, Idaho, were examined for parasites including *Anisakis*. Samples of infected chinook salmon were sent to the senior author from Barrow, Alaska.

The occurrence of anisakid larvae was tabulated. Sections from the sablefish infected with anisakine larvae were studied in the laboratory using light microscopy.

Results and Discussion

All of the 25 sablefish from Alaska were infected with anisakid larvae. The number of larvae found in each fish ranged from 1 to 11. Five fish had infections in the liver, four infections in musculature of the body wall, and the other larvae were found in the other viscera. The musculature infections could be due to worm migration following death of the host. These data correlate with Meyers (1979) with the exception of more worms per host in Alaska. No gross lesions were evident at the infection site except for one case where the anisakid larvae occupied an area near the epidermis of the skin. Prepared histological slides displayed a chronic inflammatory response for infected liver and muscle (Figs. 1 and 2). The host response consisted of organ compression, collagenous tissue encapsulation (Fig. 3), and cellular exudate forms, including free macrophages, lymphocytes, heterophils, fibroblasts, and occasional eosinophils in the area. These cells characterize an inflammatory response by the host. Migratory pathways were also observed for anisakid infected fish tissue. Observations for our infected fish tissue correlated with studies done elsewhere (Wootten 1978).

Host cell necrosis was associated with anisakid larvae in both the liver and muscle (Figs. 1 and 2). Hepatocytes had pyknotic nuclei, reduced cell size, and cytoplasmic eosinophilia. Organ compression was evident adjacent to the collagenous tissue capsule (Fig. 3).

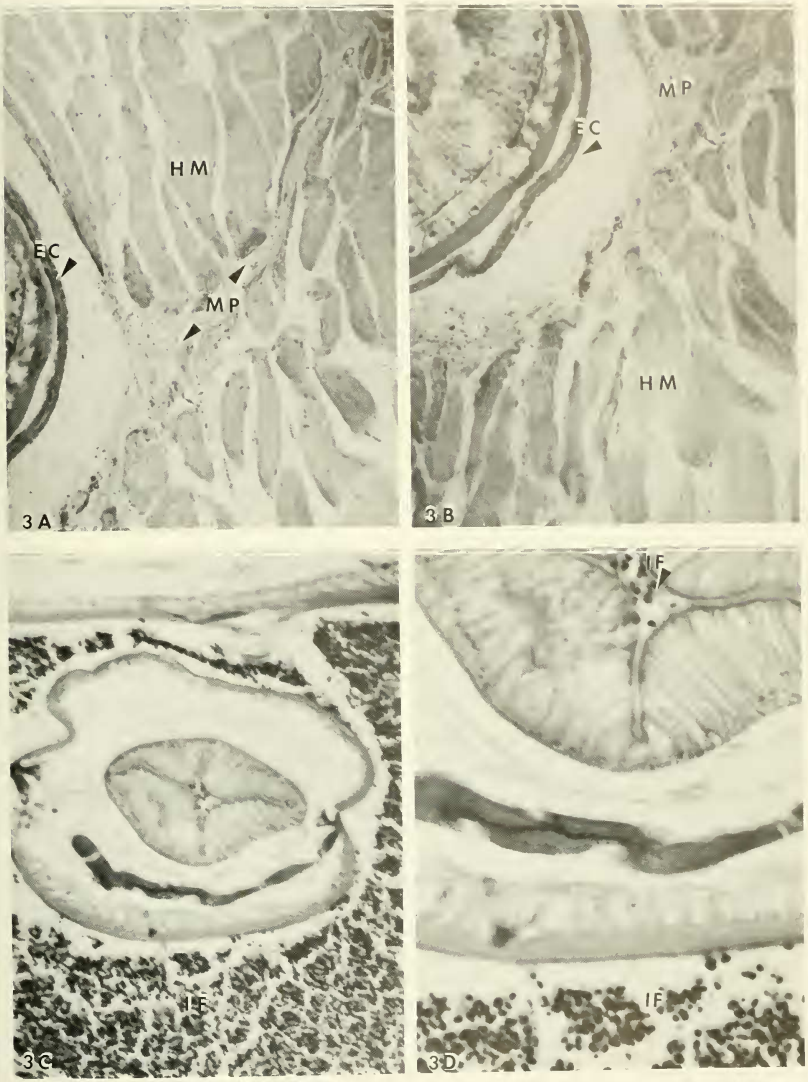

Fig. 3. These four pictures depict the inflammatory response and migratory pathway of an anisakid nematode larva. Micrograph 3A shows the route followed by the migrating anisakid (MP) through the host musculature (HM) followed by the formation of a prominent capsule (EC) depicted by figure 3B. The inflammatory response (IF) caused by the larval anisakid is shown by 3C and 3D. Note the dark-staining nature of the cells characteristic of lymphocytes, macrophages, and granular white blood cells. Note for 3D that host inflammatory cells (IF) are in the digestive tract in the anisakid worm (3C; 400×) (3D; 100×).

Small anisakid larvae were observed in a dermal papilla measuring 1 cm in diameter near the anal orifice of one fish. The papilla was raised 1–2 mm and was pale in color. Microscopic examination of the papilla showed numerous encapsulated larvae with associated inflammatory response from host tissue.

Many surveys have been conducted to determine the incidence of anisakid larvae in fish. Due to the human potential of anisakiasis, it is recommended that fish reported to be hosts for anisakids be properly cooked and prepared for consumption.

These data extend the known northern geographical distribution of anisakid larvae in sablefish to Alaska. During 1980 the first author received a specimen of chinook salmon from Barrow, Alaska, that contained an anisakid larvae (Heckmann 1980). Four of the 10 salmon examined in Idaho were infected with the roundworm. The spawning fish had carried their roundworm parasites several hundred miles inland from the Pacific ocean.

LITERATURE CITED

CARVAJAL, J., C. BARROS, G. SANTANDER, AND C. ALCALDE. 1981. In vitro culture of larval anisakid parasites of the Chilean Hake *Merluccius gayi*. J. Parasit. 67:958–959.

CATTAN, P. E., AND N. N. VIDELA 1976. Presencia de larvas de *Anisakis* sp. en el Jurel, *Trachurus murphyi* Nichols, 1920 (Algunas consideraciones sobre su relacion con el granulom a eosinofilico en el hombre). Biol. Chile Parasitology 31:71–74.

DAILEY, M., L. JENSEN, AND B. WESTERHOF HILL. 1981. Larval anisakine roundworms of marine fishes from southern and central California, with comments on public health significance. California Fish and Game 67:240–245.

DAVEY, J. T. 1972. The incidence of *Anisakis* sp. larvae in the commercially exploited stocks of herring (*Clapea harengus*) in British and adjacent waters. J. Fish Biol. 4:535–554.

HADIDJAJA, P., H. D. ILAHUDE, H. MAHFUDIN, AND M. HUTOMO. 1978. Larvae of Anisakidae in marine fish of coastal waters near JaKarta, Indonesia. Amer. J. Trop. Med. Hygiene 27:51–54.

HAUCK, A. K. 1977. Occurrence and survival of the larval nematode *Anisakis* sp. in the flesh of fresh, frozen, brined, and smoked Pacific herring. *Clupea havengas* Pallasi. J. Parasit. 63(3):515–519.

HECKMANN, R. A. 1981. Personal observation of chinook salmon from Barrow, Alaska.

HUMASON, G. L. 1972. Animal tissue techniques. W. H. Freeman and Co., San Francisco. 641 pp.

JACKSON, G. L. 1975. The "new disease" status of human anisakiasis and North American cases: a review. J. Milk Food Technol. 38:769–773.

KATES, S. 1973. A case of human infection with the cod nematode *Phocanema* sp. Amer. J. Trop. Med. Hygiene 22:606–608.

MIGAKI, G., R. A. HECKMANN, AND T. F. ALBERT. 1982. Gastric nodules caused by "Anisakis type" larvae in the Bowhead whale (*Balaena mysticetus*). J. Wildlife Diseases 18:353–358.

MYERS, B. J. 1970. Nematodes transmitted to man by fish and aquatic animals. J. Wildlife Diseases 6:266–271.

———. 1975. The nematodes that cause anisakiasis. J. Milk Food Technol. 38:774–782.

———. 1979. Anisakine nematodes in fresh commercial fish from waters along the Washington, Oregon, and California coasts. J. Food Protection 42:380–384.

MORBIDITY AND MORTALITY WEEKLY REPORT. 1975. Epidemiologic notes and reports anisakiasis—California. Morbidity and Mortality Weekly Report, U.S. Department Health, Education, and Welfare, CDC, Atlanta, Georgia, Sept. 27, 1975: 339–340.

ONO, Y. 1975. Anisakiasis as a parasitic zoonosis and its prevention. Animal Husbandry 29(4):497–500, 29(5):605–610.

OSHIMA, T. 1972. *Anisakis* and anisakiasis in Japan and adjacent areas. Pages 301–393 *in* K. Morishita, Y. Komiya and H. Matsubayashi, eds., Progress of Medical Parasitology in Japan. Meguro Parasitological Museum, Tokyo. Vol. IV.

PRUSEVICH, T. O. 1964. On the formation of capsules around larvae of *Anisakis* sp. in the tissues of the shorthorn sculpin *Myxocephalus scorpius*. Trudy Murmanskogo Biologcheskogo Instituta 5: 265–273.

SHIRAKI, T. 1974. Larval nematodes of the family Anisakidae (Nematoda) in the northern Sea of Japan—as a causative agent of eosinophilic phegmone or granuloma in the gastro-intestinal tract. Acta Medica et Biologia 22:57–98.

SMITH, J. W. 1971. *Thysanoessa inermis* and *T. longicaudata* as first intermediate hosts of *Anisakis* sp. (Nematoda: Ascaridata) in the Northern Sea, the north of Scotland, and at Faroe. Nature 234(5330): 478.

SMITH, J. W., AND R. WOOTTEN. 1975. Experimental studies on the migration of *Anisakis* sp. larvae (Nematoda: Ascaridida) into the flesh of herring, *Clupea harengus* L. Int. J. Parasitiol. 5:133–136.

———. 1978. Anisakis and anasakiasis. Pages 93–163 *in* W. H. R. Lumsden, R. Muller, and J. R. Baker, eds., Advances in Parasitology. Academic Press, New York. Vol. 16.

TORRES, P., E. HERNANDEZ, AND I. SANDOVAL. 1983. Anisakiasis and Phocanemiasis in marine fishes from the south of Chile. Int. J. Zoonoses 10:146–150.

VIK, R. 1964. Penetration of stomach wall by anisakis-type larvae in porpoises. Canadian J. Zoology 42:55.

WOOTTEN, R. 1978. The occurrence of larval anisakid nematodes in small gadoids from Scottish waters. J. Mar. Biol. Assoc. V.K. 58:347–356.

WOOTTEN, R., AND J. W. SMITH. 1975. Observational and experimental studies on acquisition of *Anisakis* sp. larvae (Nematoda: Ascaridida) by trout in fresh water. Int. J. Parasitol. 5:373–378.

WOOTTEN, R., AND J. F. WADDELL. 1977. The occurrence of larval nematodes in the musculature of cod and whiting from Scottish waters. J. du Conseil Int. Explor. Mer 37:266–273.